Miles to Go Before I Sleep: Sleep/Wake Issues in the Workplace

Lee K. Brown MD

Professor of Medicine and Pediatrics

and Vice Chair

Department of Internal Medicine,

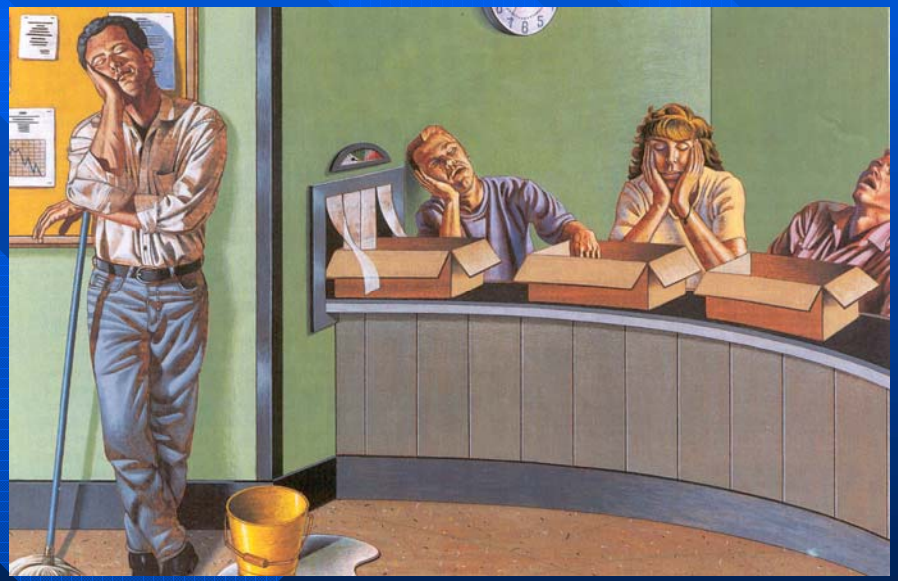
University of New Mexico

School of Medicine

Executive Director,

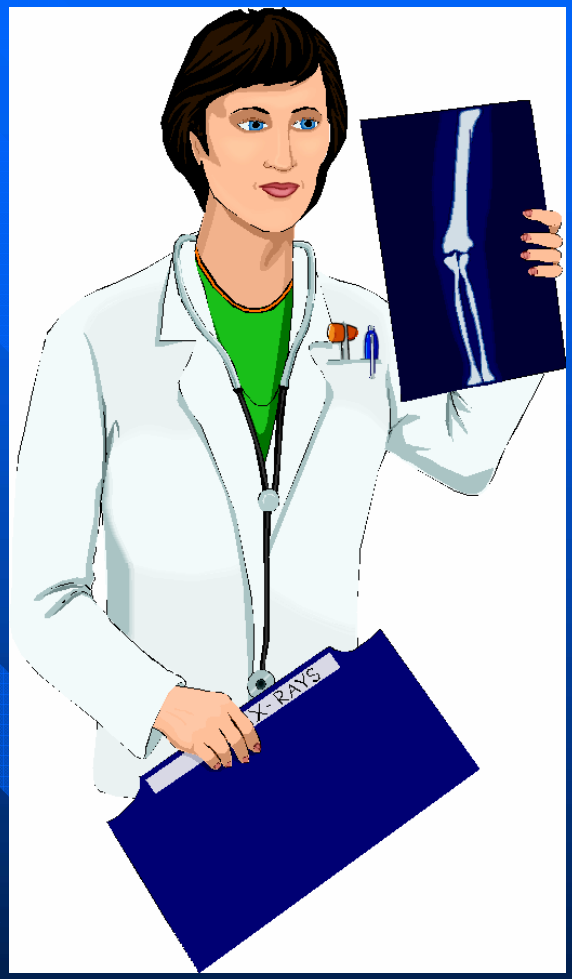
UNM-HSC Program in Sleep Medicine

Albuquerque, New Mexico



The woods are lovely, dark and deep.
But I have promises to keep,
And miles to go before I sleep,
And miles to go before I sleep.

Robert Frost, *Dust of Snow*, 1923

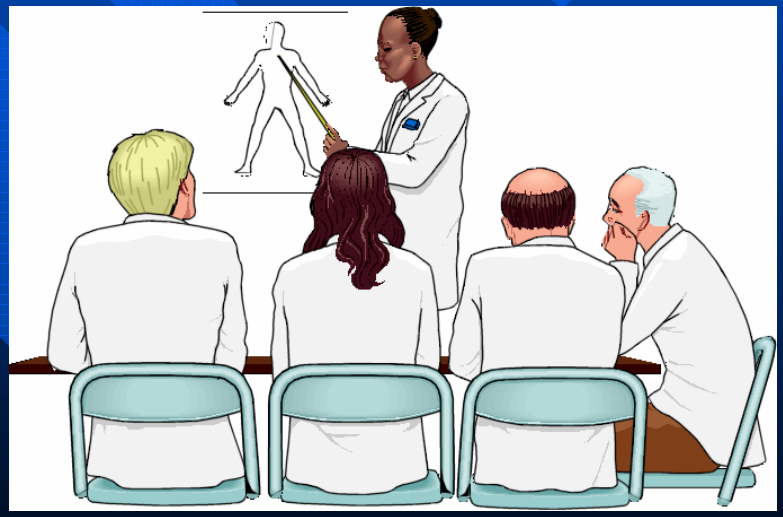


My mind clicks on and off…I try letting one eyelid close at a time while I prop the other open with my will. My whole body argues dully that nothing, nothing life can attain, is quite so desirable as sleep. My mind is losing resolution and control.

***Charles Lindbergh*, The Spirit of St. Louis**

Lecture Overview

- Sleep physiology
- Consequences of Sleep Deprivation/Fragmentation
- Sleep Deprivation in the Workplace
- Countermeasures

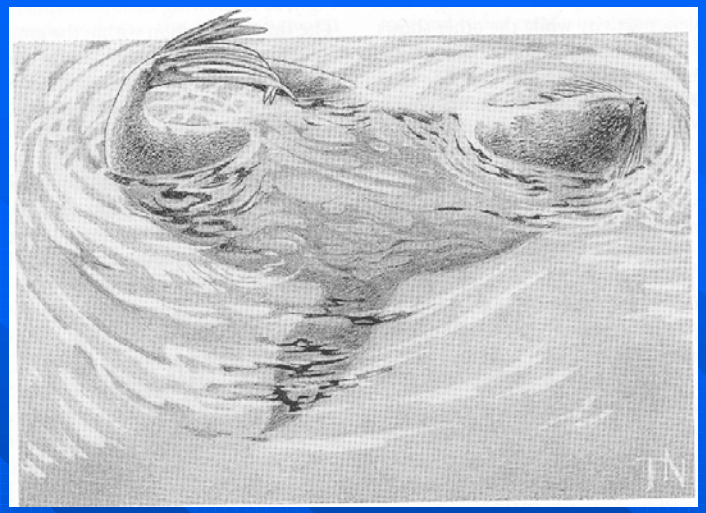


What is Sleep?

"A reversible behavioral state of perceptual disengagement from, and unresponsiveness to, the environment"

– *Carskadon and Dement, 1989*

Behavioral Criteria for Sleep



- Quiescence
- Stereotypic, species-specific posture
- Increased arousal threshold
- Rapid waking with moderately intense stimulation
- Rebound recovery from deprivation

Why Do We Sleep?

- Restorative
  - Brain
    - Recovery of CNS neurons which undergo reversible change during wakeful activation
    - Accumulation of chemicals/neurotransmitters (adenosine?)
    - Temperature????
  - Body
    - Synthesis, tissue repair
    - Immune function
- Cognitive (consolidate memory- REM Sleep)

Distribution of Sleep Stages

Non-REM
75-80%

Stage I----------2-5%

Stage II----------45-50%

Stage III----------3-8%

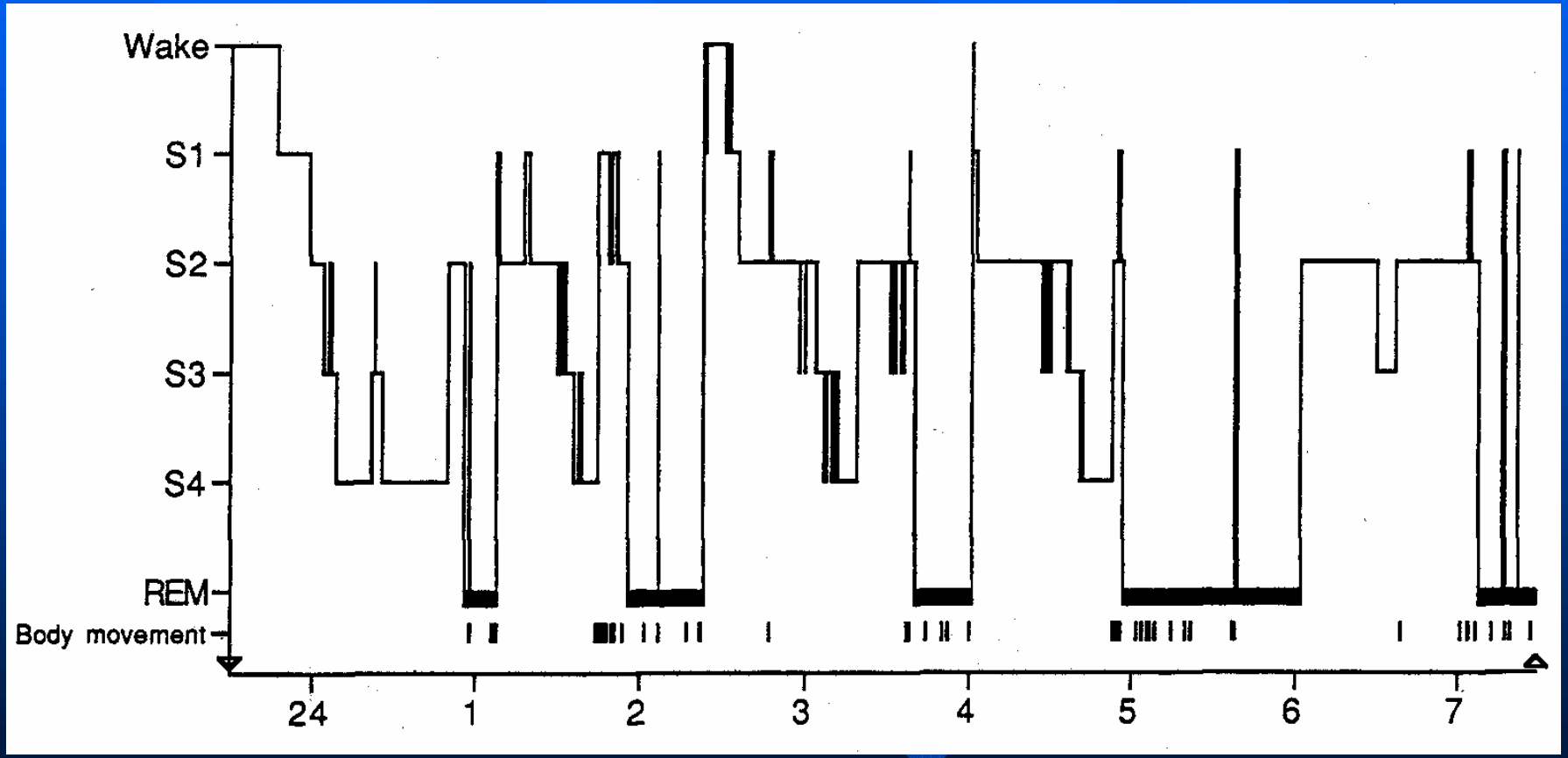
Stage IV----------10-15%

13-23%

Wake----------5%

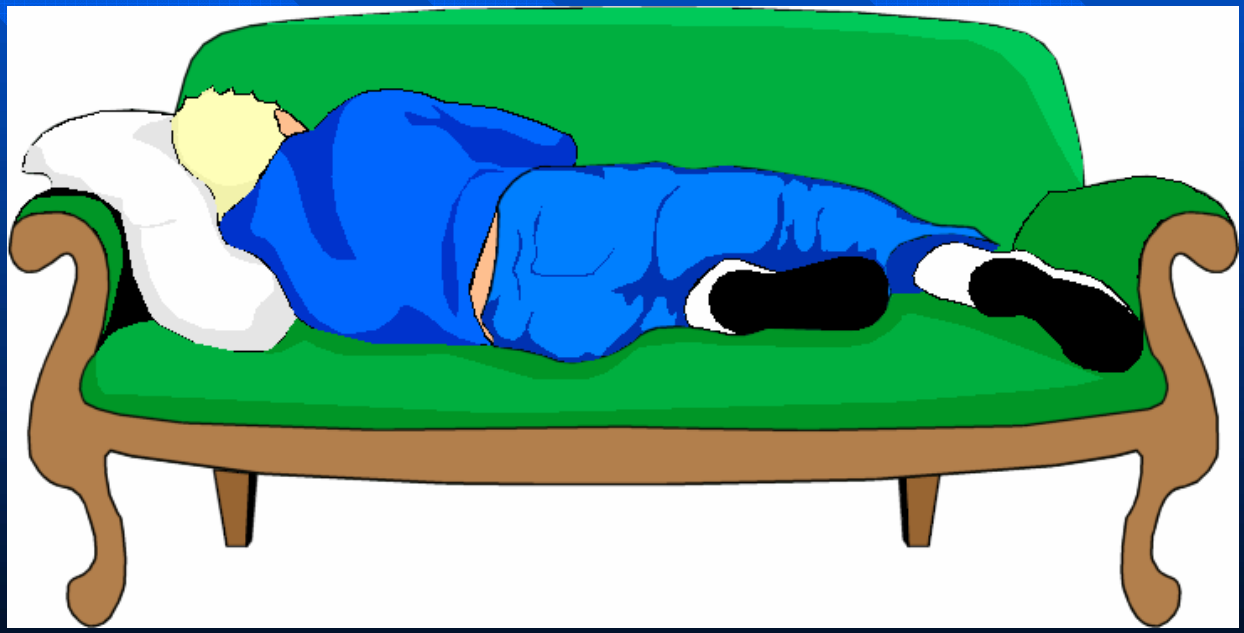
Stage REM----------20-25%

Sleep Architecture in Young Adult

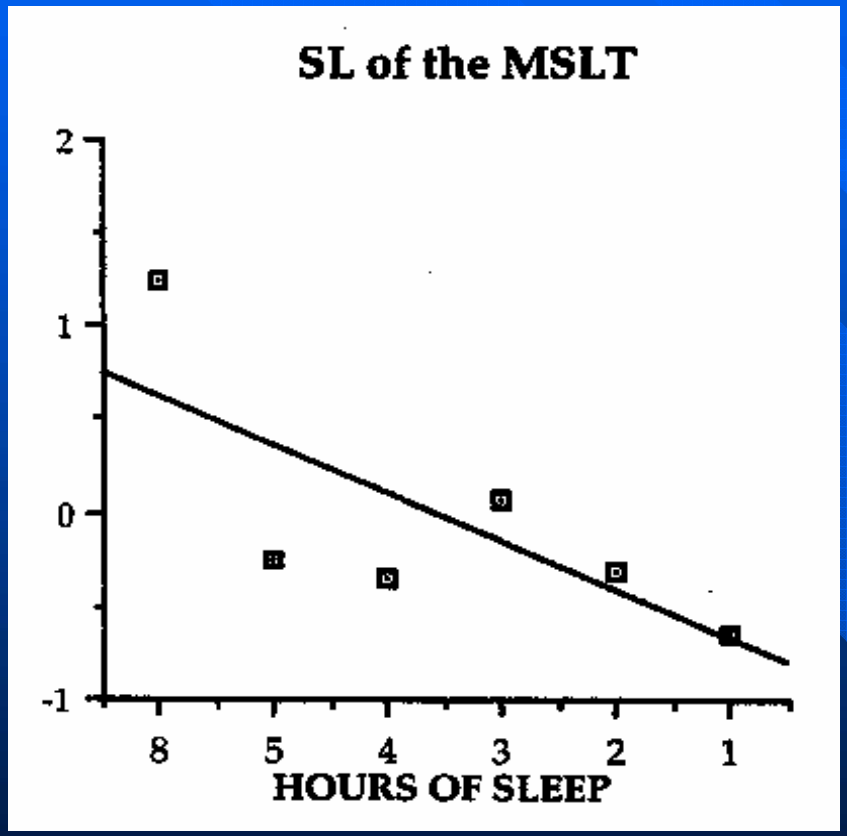


Determinants of Sleepiness

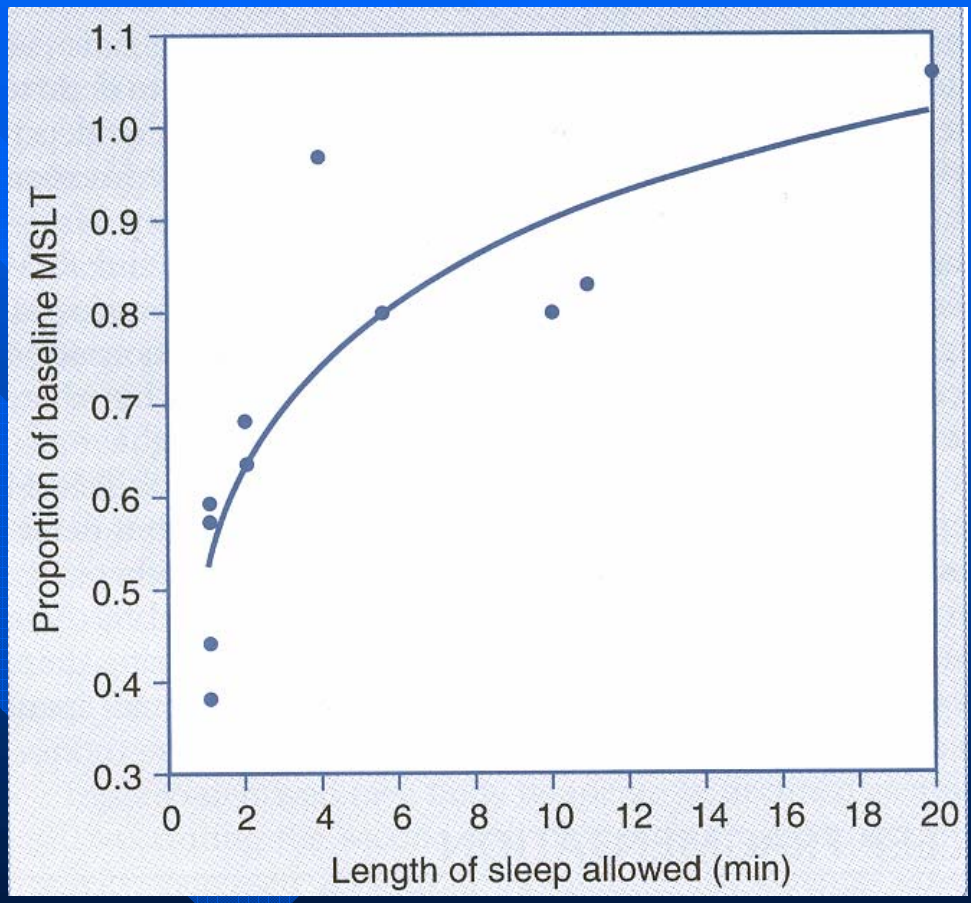
- Homeostasis/length of prior wakefulness
  ("sleep deprivation" or "sleep debt")
- Circadian Rhythm



Homeostatic Sleepiness



Devoto et al. Sleep, 1999



Bonnet & Arand. Sleep Medicine Reviews, 2003

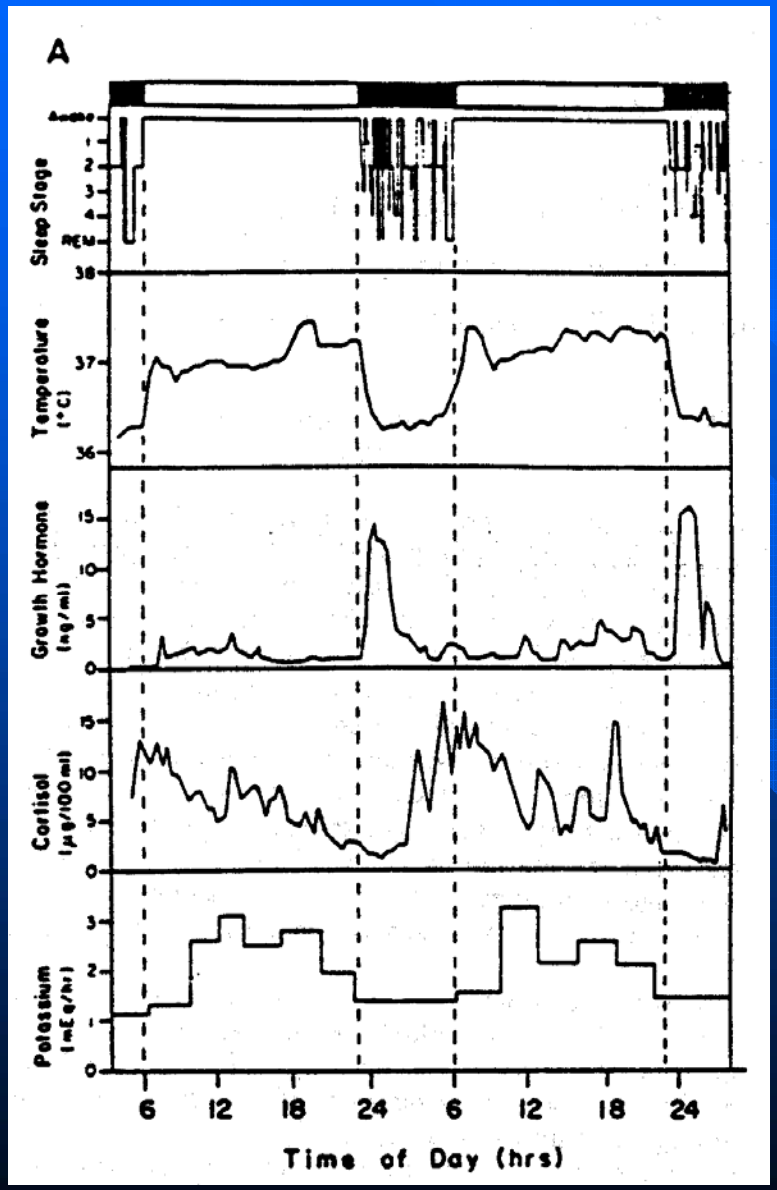
Adults on average sleep six hours and 54 minutes, about an hour less than the eight hours recommended by sleep experts.

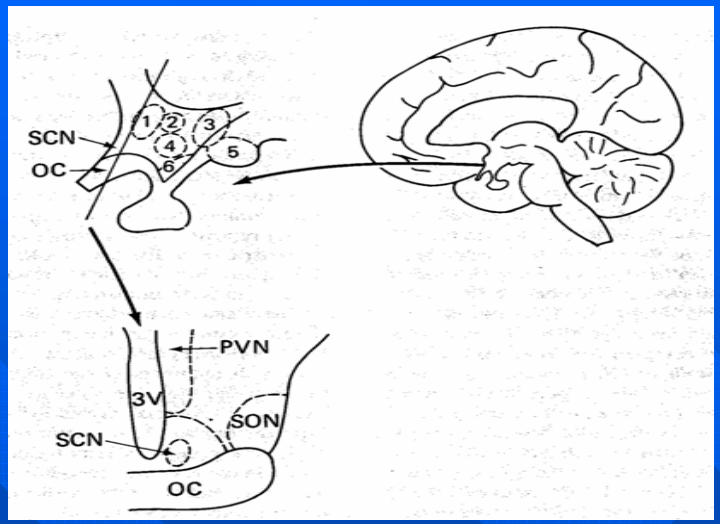
National Sleep Foundation,

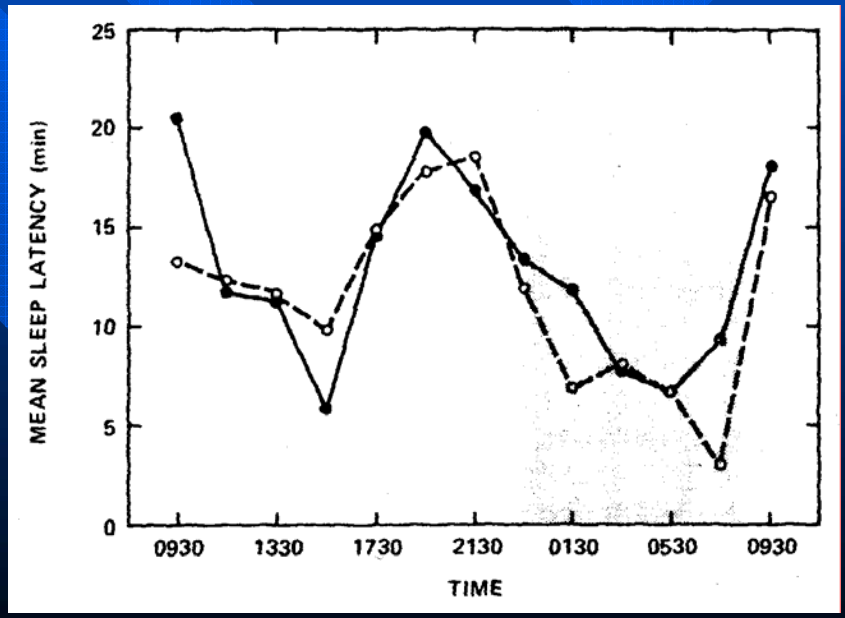
Omnibus Sleep in America Poll

2000

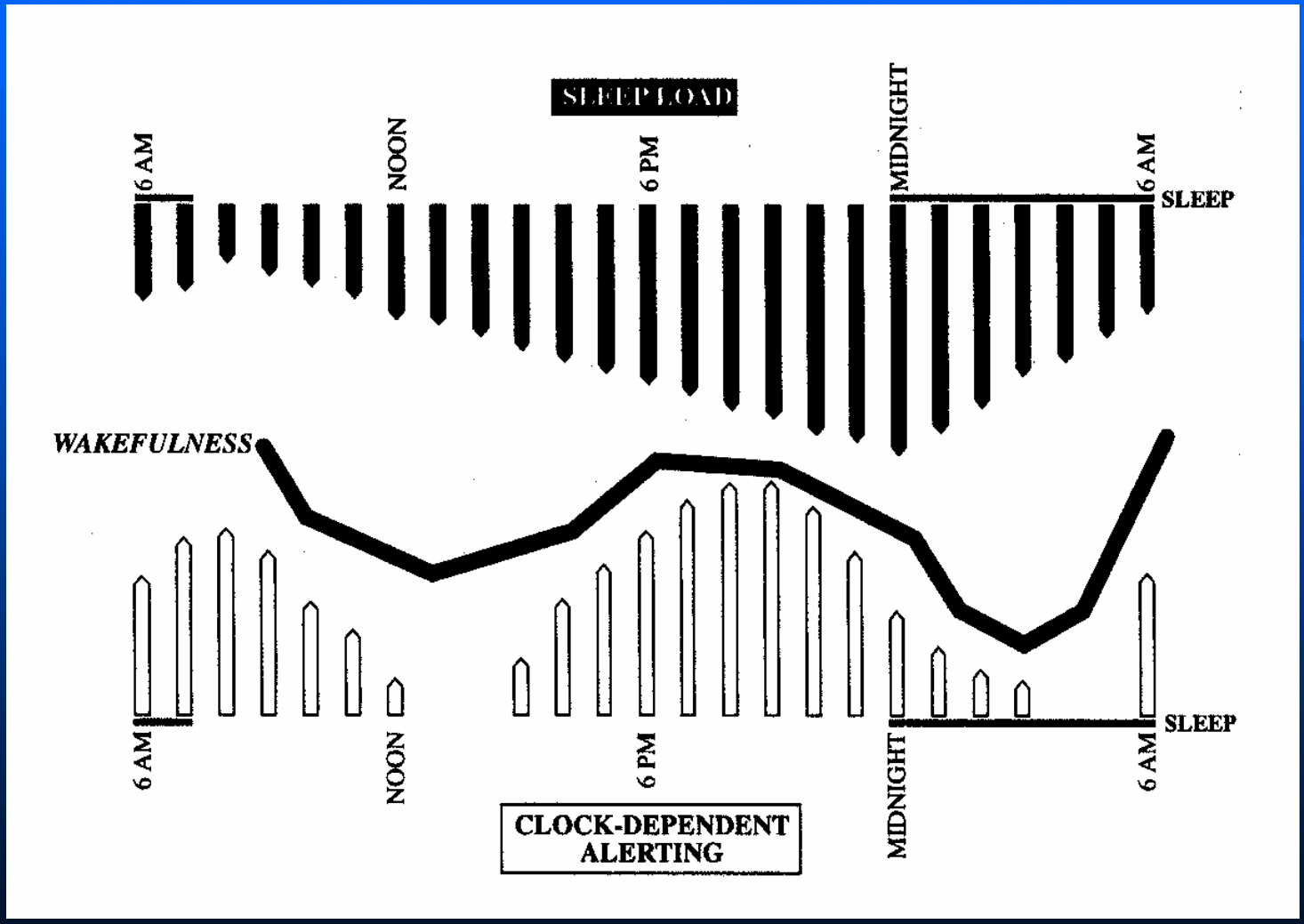
Circadian Rhythms







Interaction between Sleep Debt (S) and Circadian Variation in Alerting Mechanism (C)

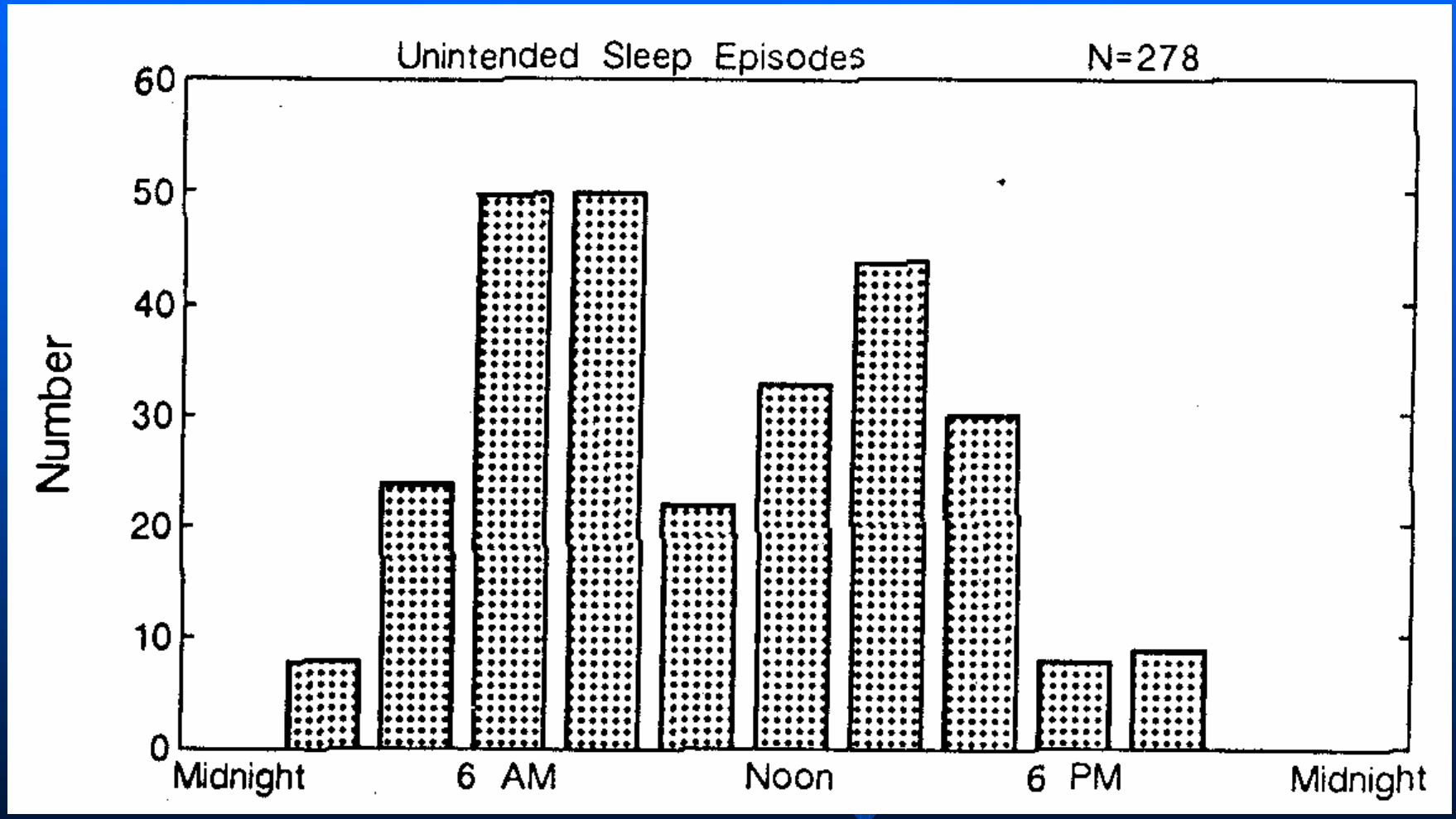


Demonstrated Behavioral Adverse Effects of Acute Total Sleep Deprivation, Chronic Partial Sleep Deprivation, and Circadian Sleepiness

- Vigilance
- Cognitive tasks
- Motor tasks
- Verbal processing
- Complex problem-solving
- Learning
  - Complex cognitive tasks
  - Procedural tasks
- Mood

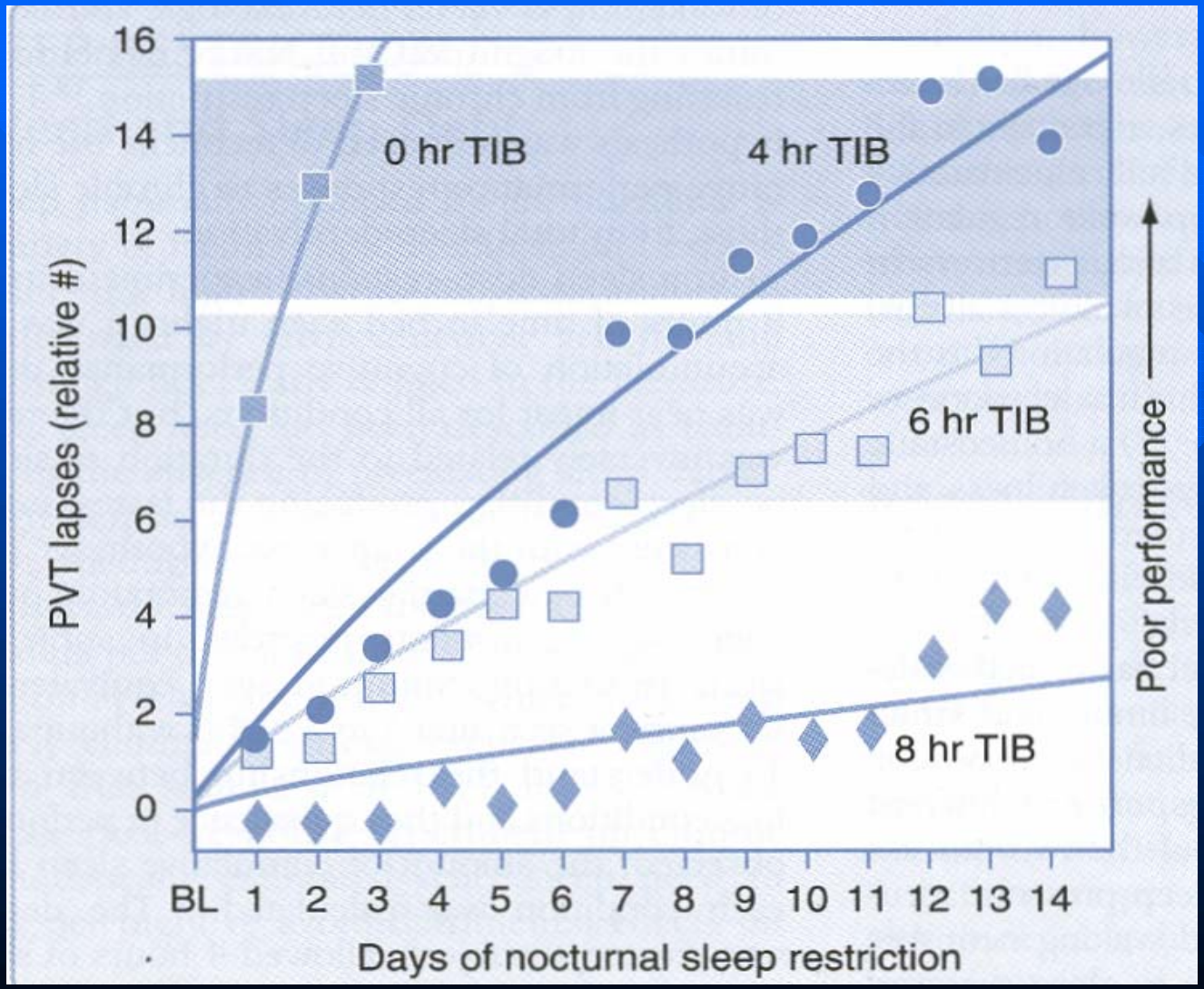
Sources:
Pilcher and Huffcutt. Effects of sleep deprivation: A meta-analysis. Sleep 1996
Veasey et al. Sleep loss and fatigue in residency training. A reappraisal. JAMA 2002

Circadian Variation in Unintended Sleep Episodes

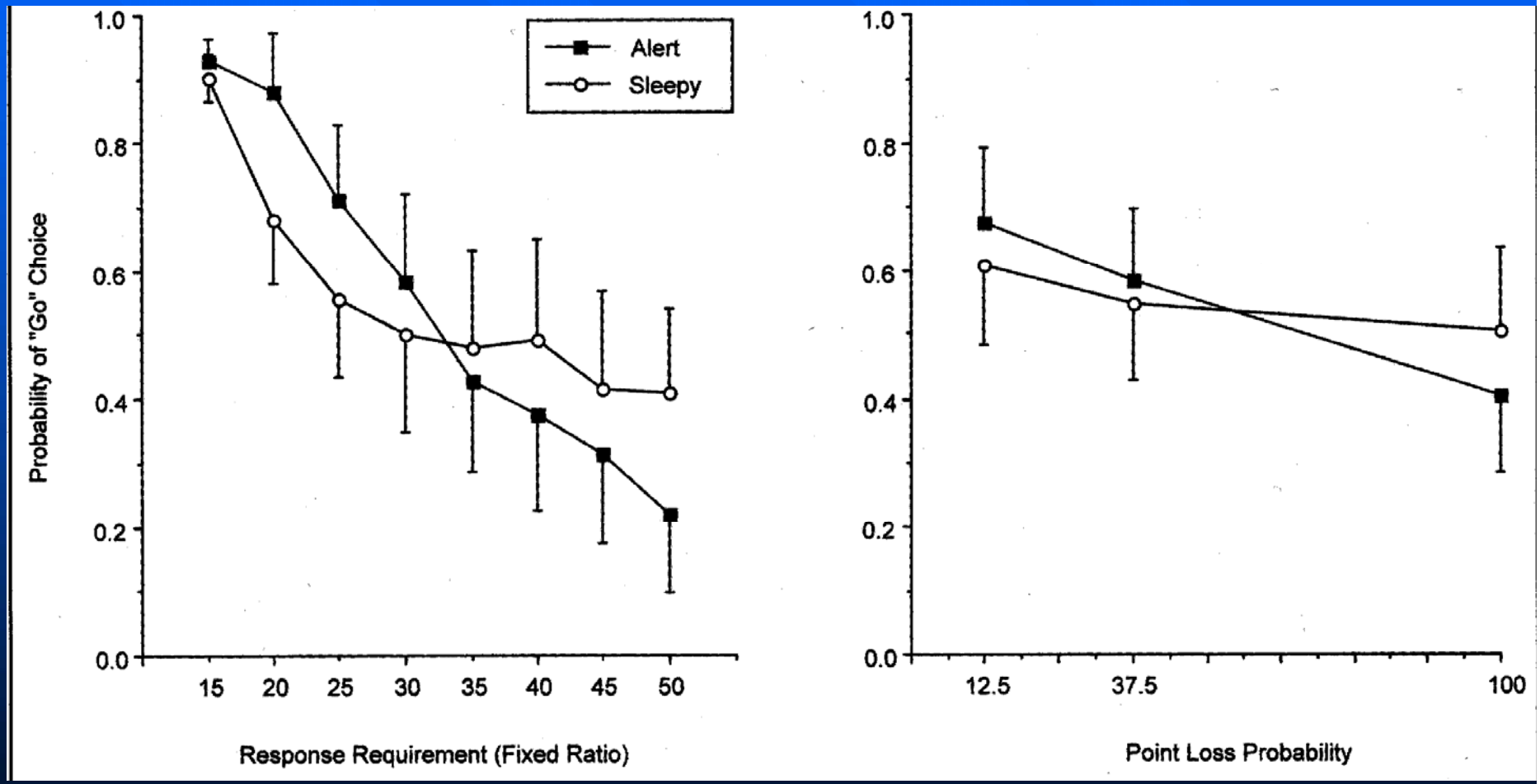


From Carskadon et al.

Psychomotor Vigilance Test: Performance Lapses under Varying Doses of Daily Sleep

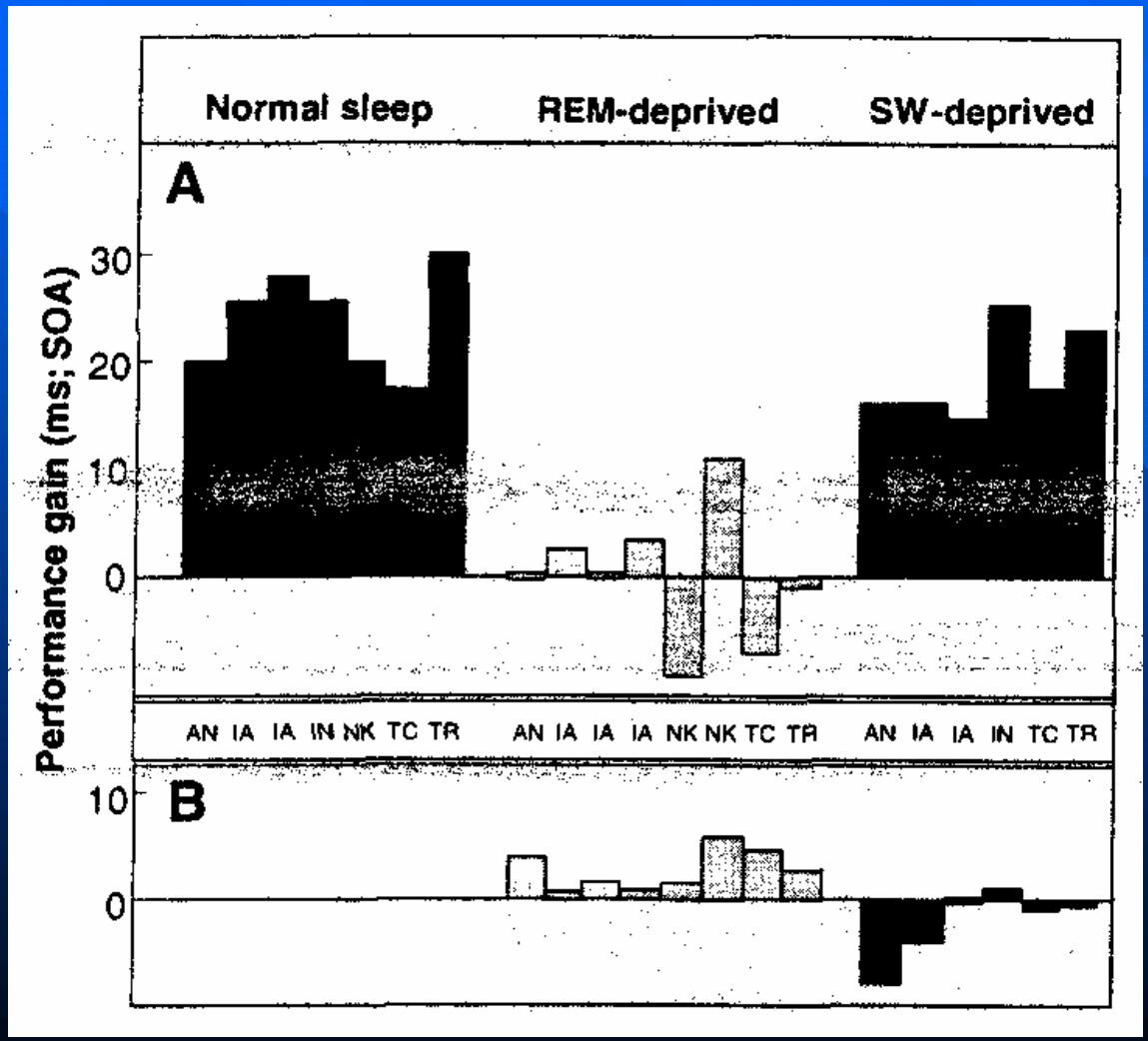


Effect of Sleep Deprivation on Risk-taking Behavior (Stop Light Task)



Roehrs et al. Sleep, 2004

Performance Gains on a Novel (A) vs. Well-practiced (B) Task without and with REM or SWS Deprivation



Karni et al. Science, 1994

Other Demonstrated Health Effects of Sleep Deprivation

- Immune Function
  - Antibody titers to vaccination
  - Febrile response to endotoxin
  - Natural killer T-cell activity
- Endocrine function
  - Leptin
  - Thyroid hormone
  - Cortisol
  - Prolactin
  - Luteinizing hormone
  - Estradiol
- Appetite and food selection
- Mortality

Med student killed in head-on collision

Death shatters hopes of his family and plans for a June '94 wedding.

By Caren Halbfinger
Staff Writer

A top third-year medical student at New Rochelle Hospital Medical Center, who was looking forward to marriage and a brilliant career as a surgeon, died early yesterday in a head-on collision on his way home to Yonkers to get some sleep.

Frank Inguilli, 24, was killed after he drove onto Interstate 95 going the wrong way at exit 15 in New Rochelle, said state Police Investigator Peter Cobb.

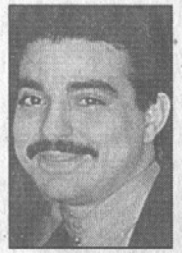
"We believe he might have been tired," Cobb said.

Inguilli entered the highway heading southbound on the northbound side of I-95. A first car avoided him, but at 1:45 a.m. his car collided head-on with a second car, driven by a 21-year-old Armonk woman.

The driver, Lisa Silverbrand, and her passenger, Dana Jung, of Floresville, Texas, were treated for cuts, abrasions, contusions and a sprain at New Rochelle Hospital Medical Center and released, Cobb said.

Inguilli's fiancee, Jodi Tobias, said he was a brilliant student at New York Medical College and a wonderful young man whose death had shattered their plans for a June 1994 wedding and the hopes of his bricklayer father and seamstress mother. He would have been the first doctor in the family.

"All his parents wanted to do was see him graduate," Tobias said. "That's what they worked for their whole lives. Everybody was waiting for that moment."



Frank Inguilli

According to New Rochelle Hospital, Inguilli left about 10:30 p.m., passing up a pizza party with colleagues for some home-cooked food at his parents' home in Yonkers.

Inguilli's sister, Margaret, said her brother had gone back to the hospital to wrap up some work and was heading home to sleep, as he often did, even though hospital rules precluded him from doing so when he was on call.

But hospital officials said the rules required that Inguilli remain on the hospital grounds unless he notified the chief resident he was leaving. An apartment is available on the grounds for medical students and hospital personnel on call, officials said.

Inguilli had begun work 6 a.m. Wednesday and was to be on call until 6 a.m. yesterday, said Dr. Robert Brandstetter, the hospital's director of medical education.

"From everything I understand, from his workload, from his on-call schedule, the attitude that he had, it would not imply that he was unusually tired or overworked," Brandstetter said.

"He was well within the limits of work hours," he said.

Hospital regulations required that he not be on call for more than 24 hours at a time and that he work the stint more than every fourth day. Inguilli had worked from 6 a.m. until 5 or 6 p.m. Monday and Tuesday, said Dr. Khoa Lai, the hospital's chief surgical resident.

On Wednesday, Inguilli had assisted Lai on an operation until 9 p.m., then returned to the on-call apartment. The other medical student working at the hospital last saw him there at 10:30 p.m.

Inguilli had completed six weeks of a three-month surgical clerkship at the hospital.

He was an A student who had graduated from New York University in 1989 after only 2½ years, Tobias said. University officials confirmed his graduation date and that he had majored in biology and minored in chemistry.

Inguilli died of severe internal injuries, including lacerations to the lungs, aorta, liver spleen and kidney, said a spokeswoman for the Westchester County medical examiner.

He was pronounced dead at 3:30 a.m. at New Rochelle Hospital.

No tickets were issued, but the accident remains under investigation, Cobb said.

Arrangements are being handled by Farenga Brothers Funeral Home in the Bronx. A wake will be held tomorrow and Sunday, and the funeral will be Monday.

Staff writer Noreen O'Donnell contributed to this report.

State rules don't apply to medical students

By Noreen O'Donnell
Staff Writer

The highly publicized death of Libby Zion nine years ago prompted the state of New York to regulate the hours of medical interns and residents.

But the rules do not apply to medical students like Frank Inguilli, the third-year New York Medical College student killed early yesterday as he drove the wrong way on Interstate 95.

Police think he mistook the ramp because he was tired.

Teaching hospitals like New Rochelle Hospital Medical Center, where Inguilli was doing a surgical clerkship, set their own policies.

"Each institution tries to use common sense as they make a policy to limit the amount of time that students are responsible for any patients," said Dr. Robert Brandstetter, the director of medical education at the hospital.

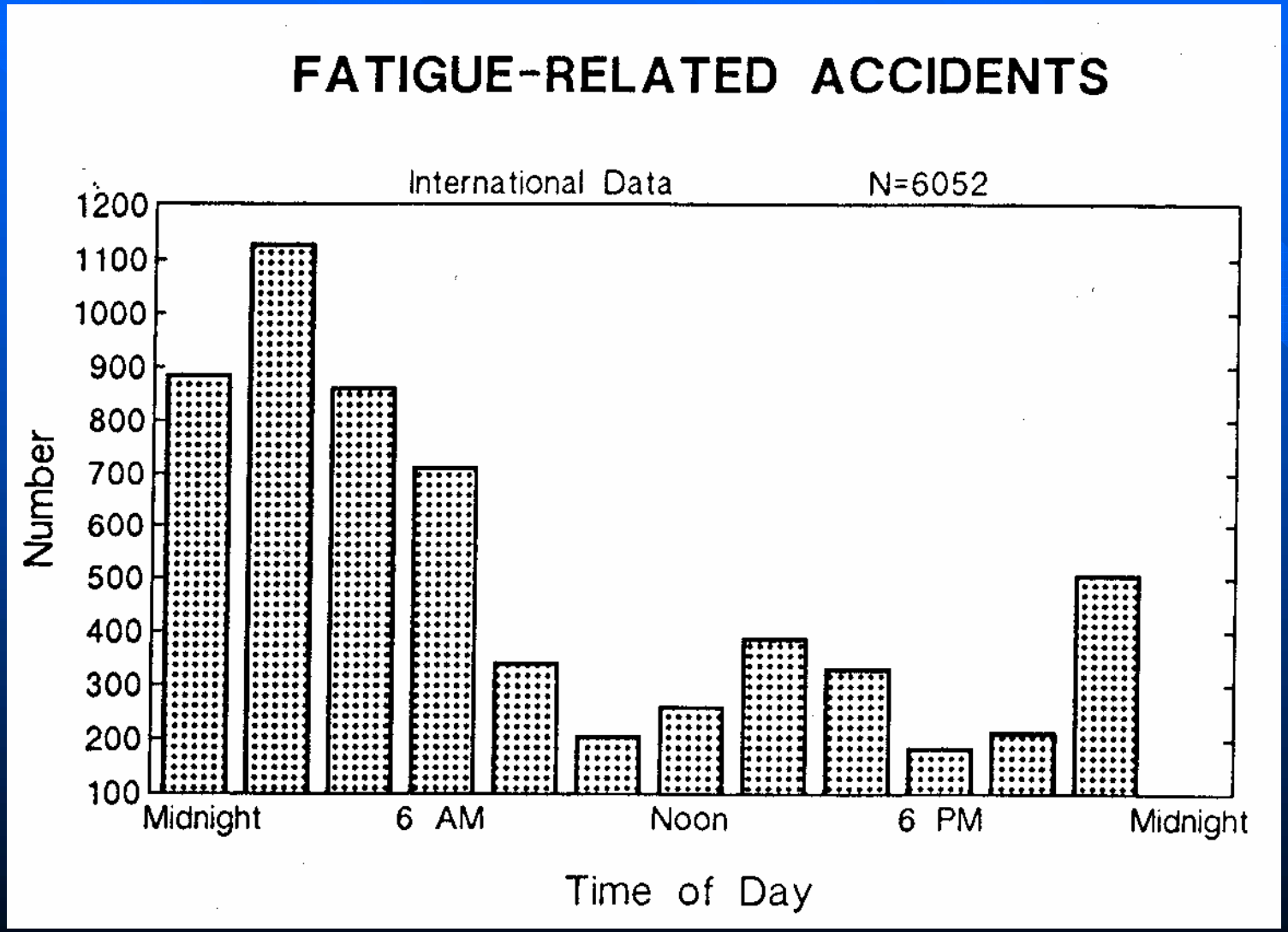
New Rochelle Hospital, for instance, limits 24-hour shifts during which students are on call to once every four days, Brandstetter said. That is less onerous than the state regulations.

The state requires that interns and residents not work more than an average of 80 hours a week over a four-week period, nor take care of patients for more than 24 hours at a time.

Until the rules went into effect in 1989, they might have been on call for 36 straight hours.

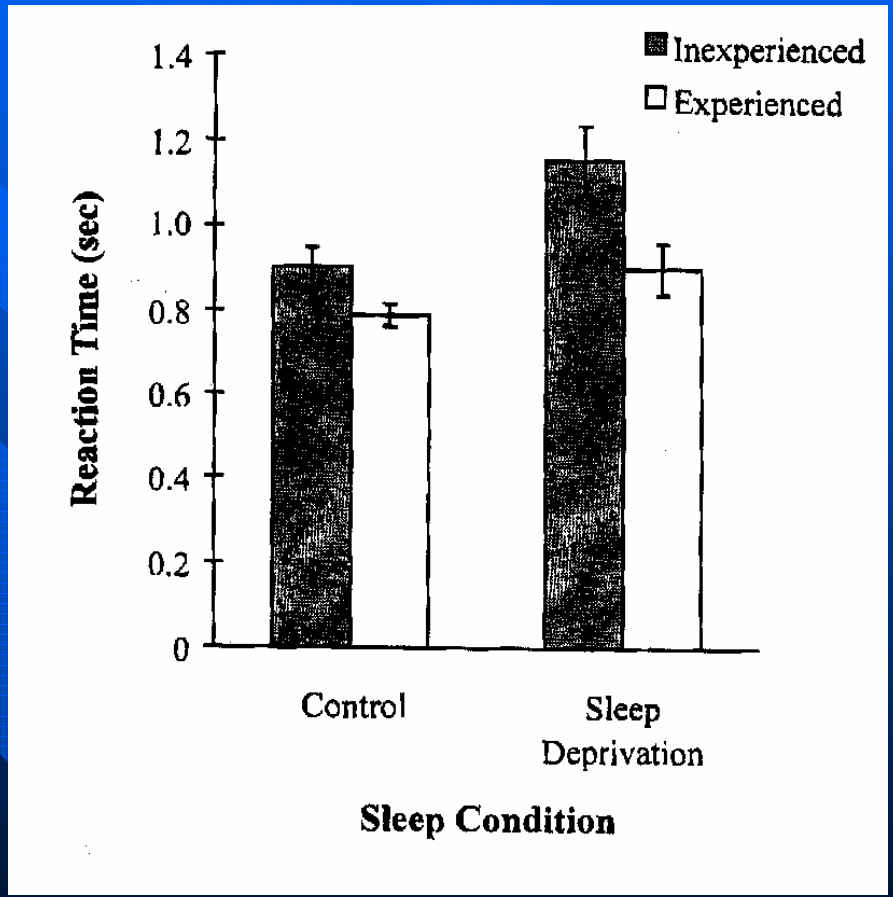
Mitler et al, Sleep 1988

(Combined data from Lavie et al, Langlois et al, and Duff)



Interactive Effects of Sleep Deprivation, Time of Day, and Driving Experience on a Driving Task. Lenné et al, Sleep 1998

- 12 experienced (>6 yrs) and 12 inexperienced (<3 yrs) drivers
- STI Driving Simulator, rural winding two-lane highway
- Task: maintain position in left lane at 80 km/hour for 4.5 minutes; secondary task of sounding horn when prompted
- Two days of testing: control and after 24 hours sleep deprivation
- Tested at 0800, 1100, 1400, 1700, and 2000 hours



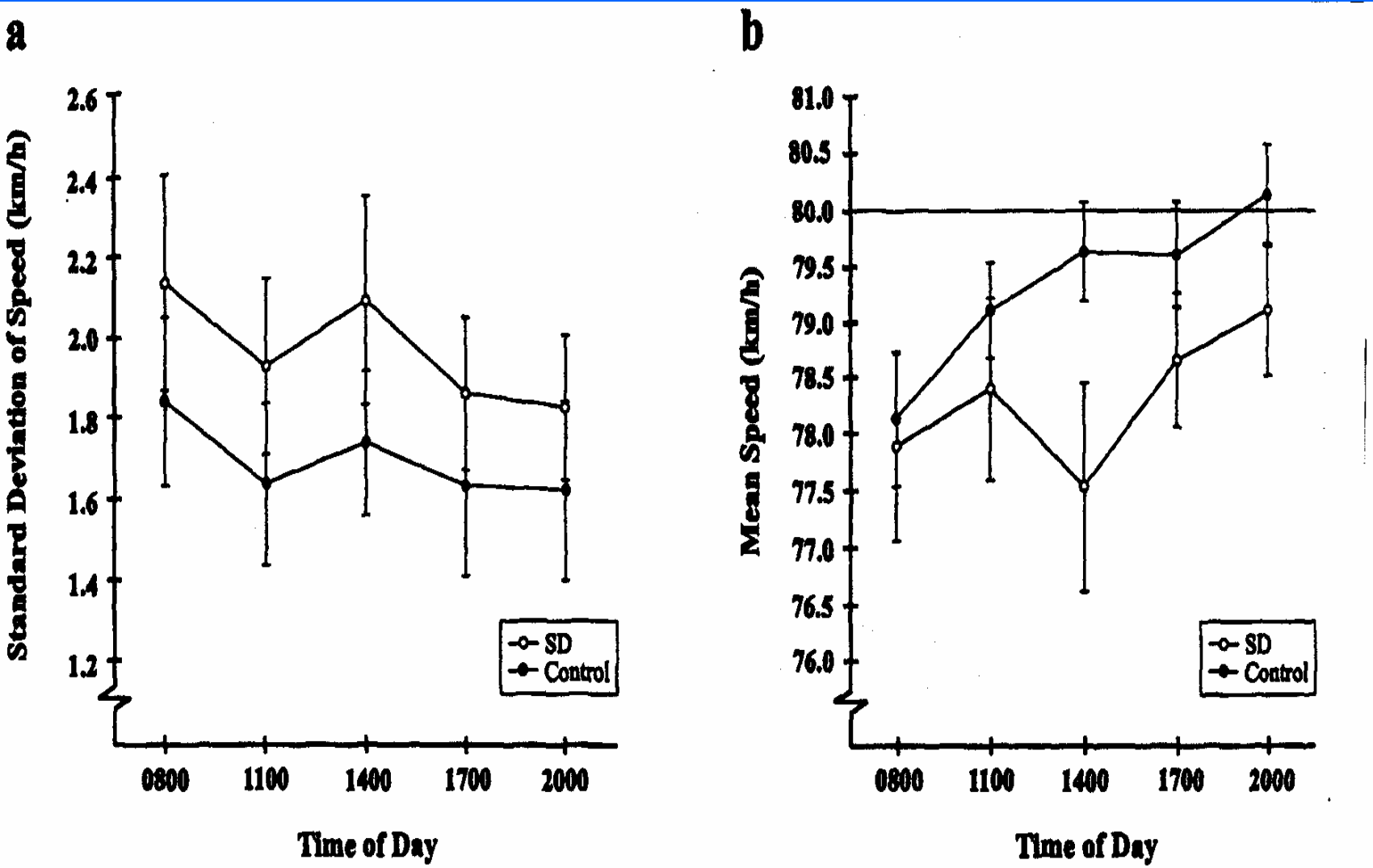


Figure 3.—a) Standard deviation of speed (km/hour) and b) mean speed (km/hour) across the day during control and SD conditions (±SE). The line at 80 km/hour represents the speed that subjects were asked to maintain.

Sleep-deprived subjects varied their speed and deviated from the target speed more than controls

Lenné et al, Sleep 1998

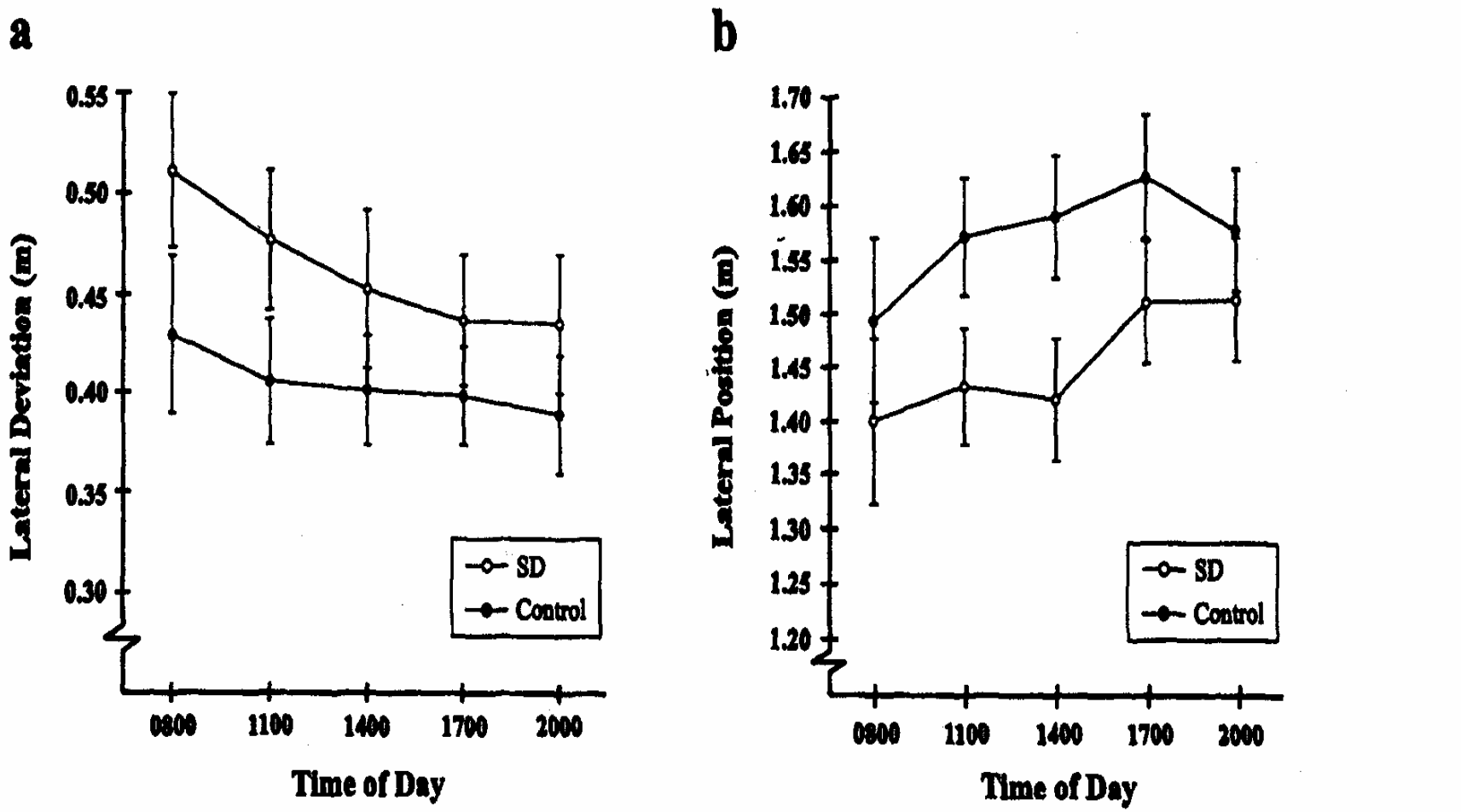


Figure 2.—a) Standard deviation of lateral position (m) and b) mean lateral position (m) across the day during control and SD conditions (±SE). The mean lateral position reflects the deviation towards the left edge of the road from the midline (middle of road).

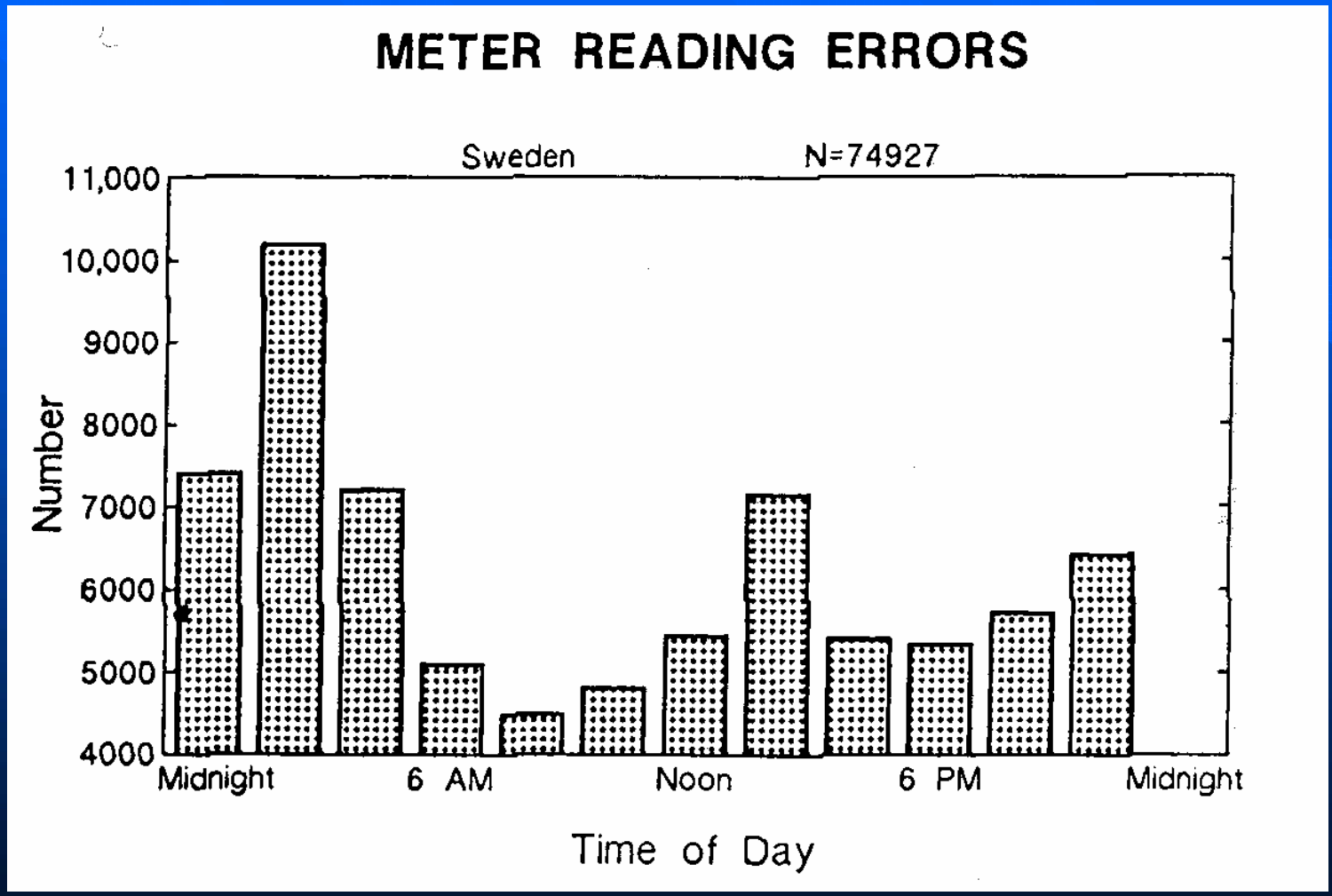
Sleep-deprived subjects varied their lateral position and deviated from the target position more than controls

Lenné et al, Sleep 1998

Sleepiness-related Disasters

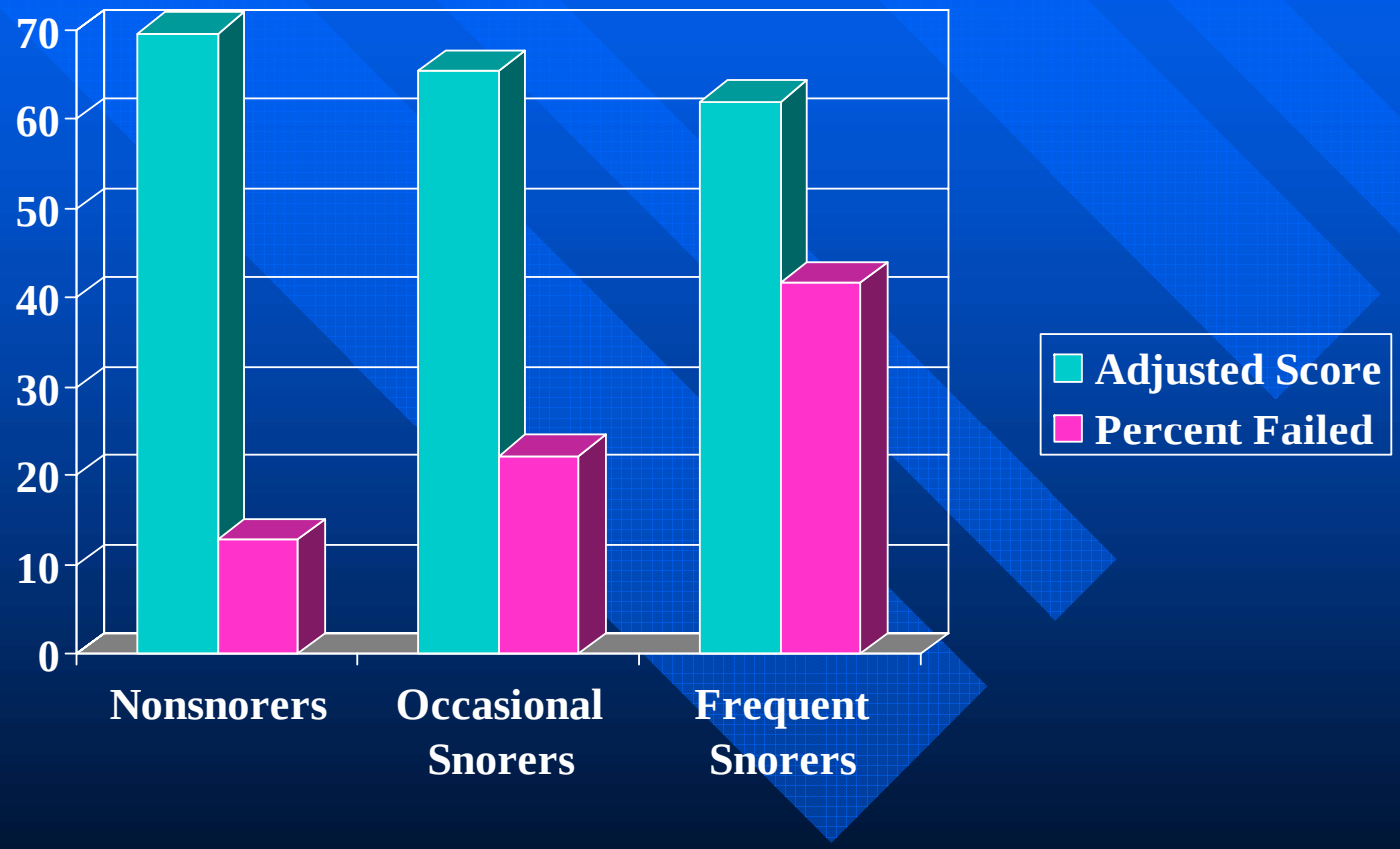
- ***Exxon Valdez***
  - Third mate too sleepy to maneuver the vessel properly
- ***Challenger***
  - Two of the three NASA managers responsible for approving the flight had <3 hours of sleep for 3 consecutive nights
- Staten Island Ferry Crash
  - Pilot “loses consciousness”
- Nuclear Reactor Accidents
  - Chernobyl
  - Three Mile Island
  - Davis-Besse
  - Rancho Seco

Mitler et al, Sleep 1988
(Data from Bjerner et al, Br J Ind Med 1955)



Are Snoring Medical Students at Risk of Failing their Exams?

Ficker JH et al. Sleep 1999



(n=78) (n=99) (n=24)

The Intern and Sleep Loss.
Friedman et al, NEJM 1971

- 14 IM interns (PGY-1)
- In random order, tested when “rested” and post-call
- Modified Jarvik Questionnaire and Mood Adjective Check List
- Abnormal ECG rhythm strip (20’) with cash prize; number of errors tallied
- Error rate±SEM= 9.64±1.41 vs. 5.21±0.93, p<0.01

Table 1. Mood Factors.*

Factor	Rested Interns	Fatigued Interns
Aggression	5.93 ± 0.70	5.14 ± 0.58
Anxiety	4.85 ± 0.44	5.43 ± 0.70
Surgency	6.36 ± 0.80	4.00 ± 0.30†
Elation	5.71 ± 0.61	3.71 ± 0.27†
Concentration	8.86 ± 0.62	8.29 ± 0.80
Fatigue	4.50 ± 0.48	10.00 ± 0.36†
Social affection	6.57 ± 0.86	4.86 ± 0.67‡
Sadness	3.36 ± 0.13	5.21 ± 0.68†
Skepticism	4.86 ± 0.48	5.43 ± 0.54
Egotism	6.07 ± 0.71	4.64 ± 0.37‡
Vigor	8.43 ± 0.85	4.57 ± 0.53†

*Mean ± SEM.
†Fatigued significantly different from rested, p <0.01 (double-tailed t-test).
‡p <0.05.

Stresses Affecting Surgical Performance and Learning: Correlation of Heart Rate, Electrocardiogram and Operation Simultaneously Recorded on Videotape. Goldman et al. J Surg Res 1972

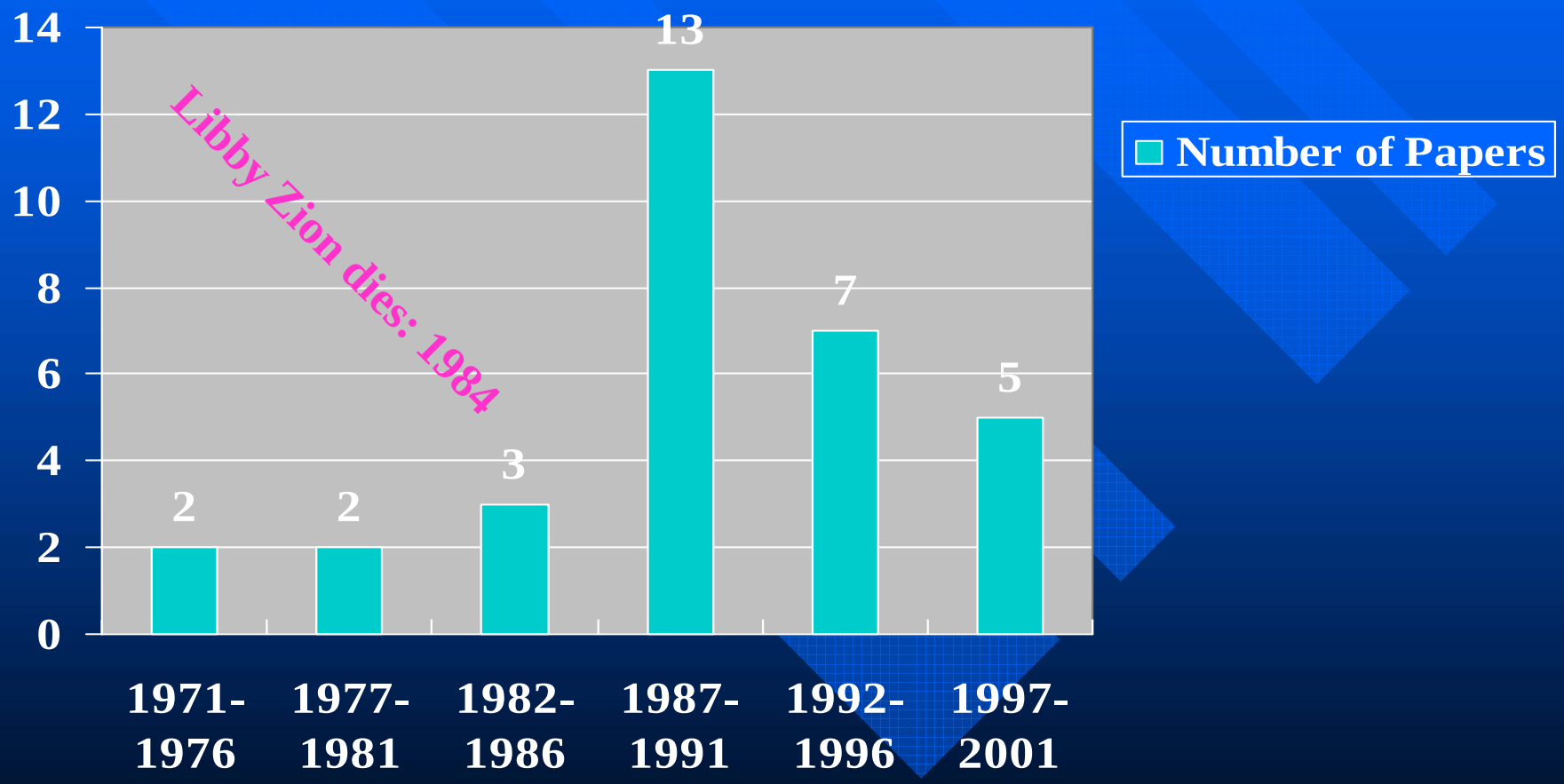
- 5 surgical residents videotaped while assisting at surgery
- Qualitative analysis of operative technique
- Not blinded
- Results: 30% more operative time required in 4/5 residents post-call (< 2 hours sleep) compared to “rested” state

Countermeasures

- Stimulants (“Go Pills”)
- Circadian Strategies
- “The most effective countermeasure for sleepiness is sleep.” Veasey et al, 2002
  - 80-hour work week (ACGME, AMA, JCAHO)
  - Chronic partial vs. acute severe sleep deprivation
  - What to do about moonlighting and other activities?
  - Napping

Peer-Reviewed Investigations of Sleep Deprivation in Graduate Medical Education

Compiled from Veasey et al, JAMA 2002



Effect of a Change in House Staff Work Schedule on Resource Utilization and Patient Care.

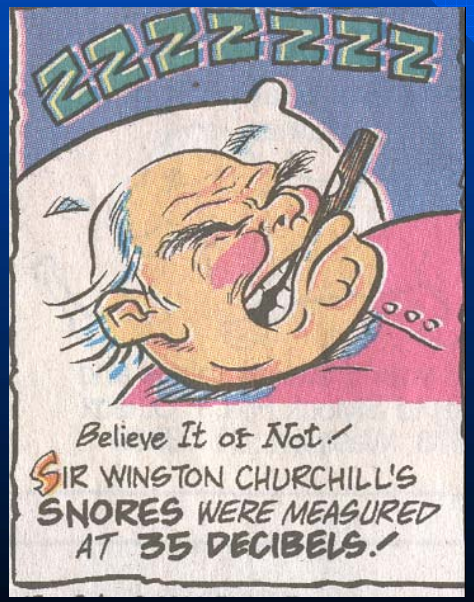
Gottlieb et al, Arch Intern Med 1991

- Minneapolis VAMC, U of Minn teaching svc
- 16 teams of PGY-1 and PGY-2 or 3
- Pre-intervention: 4-day rotation with 1 long-call night
- Post-intervention: Night-float takes admissions after 10 PM
- Long-call team slept 2.3±1.3 vs. 4.3±1.7 hours pre- and post-intervention

	Group		
	1	2	P
Length of stay, d†			
Mean ± SD	10.9 ± 14.7	9.3 ± 12.1	<.01‡
Median	7.0	5.0	<.01§
Laboratory tests, mean ± SD†‖	24.0 ± 46.0	19.0 ± 36.0	<.01
Roentgenographic studies, mean ± SD¶	4.0 ± 10.3	2.9 ± 4.5	NS
Consultations, mean ± SD¶	1.4 ± 2.3	1.3 ± 1.6	NS

Nature had not intended mankind to work from eight in the morning until mid-night without that refreshment of blessed oblivion which, even if it only lasts twenty minutes, is sufficient to renew all the vital forces. This routine I observed throughout the war, and I commend it to others if and when they find it necessary for a long spell to get the last scrap out of the human structure.

Sir Winston Churchill



What is A Nap?

- A period of sleep that is
  - shorter in duration than usual
    (typically, <50% of normal sleep period)
  - taken at a time other than the normal sleep period
  - may be prophylactic or replacement in nature

Prophylactic vs. Replacement Napping: Dinges et al, Sleep 1987

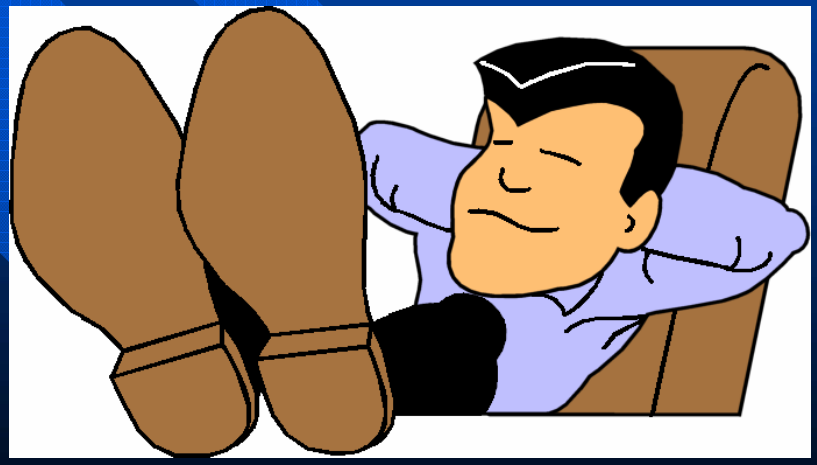
- Subjects
  - 41 healthy young adults, ages 18-30 years
  - No known history of any sleep disorder
- Protocol
  - 56 hour period of sustained wakefulness
  - Randomly assigned to nap (for 2 hours) at 6, 18, 30, 42, and 54 hours after their last night's sleep
  - Environment free of time cues
  - Performance testing (visual reaction), mood scale assessments, subjective sleepiness, and sublingual temperatures every 2.4 hours
  - Polysomnography during naps to assess sleep quality

Prophylactic vs. Replacement Napping: Results Dinges et al, Sleep 1987

- A single 2-hour nap anywhere during a 56 hour period of sustained wakefulness improved performance compared with not napping but did not return performance to normal
- Self-described mood and subjective sleepiness did not improve
- Performance improvement from prophylactic naps (6 and 18 hours after the previous night's sleep) were greater and longer lasting than for replacement naps
- Circadian timing of nap not important

What are the Drawbacks of Napping?

- Sleep Inertia
- Insomnia
- ?Lost productivity



Danger Signs for Sleepy Drivers
JAMA, 1998

- Eyes closing or going our of focus by themselves
- Trouble keeping your head up
- Yawning nonstop
- Wandering, disconnected thoughts
- Not remembering driving the last few minutes
- Drifting between lanes, tailgating, or missing traffic signs
- Jerking the car back in lane
- Drifting off the road and narrowly missing a crash

What Next?

Check with your onsite Health Benefits and Employee Services professionals or your Primary Care Provider to obtain a referral to the UNMH Sleep Disorders Center.

"If you don't think fatigue wreaks havoc, take a look at some of the laws we write around here at 1 a.m."

Rep. James Oberstar (D-MN),
quoted by *TrafficWorld* magazine, 2002